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Roots of Lodgepole Pine Seedlings Reach Depth of Only 3 to 4 Inches Their First Season

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First-season lodgepole pine seedlings only had an average rooting depth of 3.8 inches (9.6 cm), 26 branch roots, and a total root length of 9.8 inches (24.9 cm). Seedlings were field-grown in 1977 on scarified-unshaded seedbeds in the central Rocky Mountains, Colorado.

Keywords: Root development, seedling growth, *Pinus contorta*.

Root growth is important for survival of lodgepole pine seedlings (*Pinus contorta*), especially during the first growing season. Deeper root penetration will increase the chances of seedlings surviving drought, frost-heaving, and erosion.

Roots of young lodgepole pine grow slowly; seedlings often form a taproot (Bates 1930, Fowells 1965). Lotan (1964) reported that most mortality of lodgepole pine seedlings in southwestern Montana and eastern Idaho occurred early in the season and was caused by drought. Further, while root growth was not studied in detail, excavations of a few seedlings showed root growth of only 5 to 6 inches on trenched and scalped seedbeds (Lotan 1964). Sims (1964) reported an average root length of 4.7 inches (120 mm) and 23 branch roots for first-year jack pine (*Pinus banksiana* Lamb.) which hybridizes with lodgepole pine.

No information was found on root growth for first-season lodgepole pine seedlings in the

central and southern Rocky Mountains. This study was made to provide estimates of: (1) rooting depth—main root in its unextended position following washing (fig. 1); (2) number and length of unextended branch roots; and (3) total root length—rooting depth plus branch roots—for 16-week-old field-grown lodgepole pine seedlings in the central Rocky Mountains.

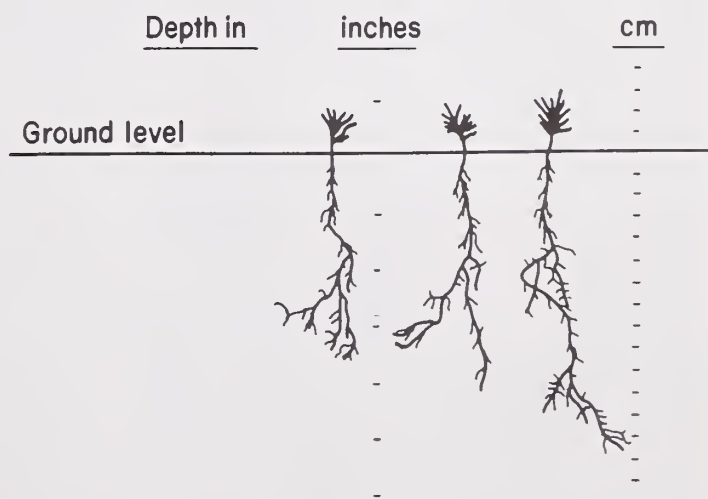


Figure 1.—Rooting depths of 16-week-old lodgepole pine seedlings.

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Study Area

Seedlings were grown on the Fraser Experimental Forest, Colorado, in what appeared to be a natural, nearly level opening of about 2 acres (0.8 ha) at an elevation of 8,900 feet (2,713 m). Dominant vegetation surrounding the opening is second growth, 60-year-old lodgepole pine with an understory dominated by whortleberry (*Vaccinium* spp.) and kinnikinnick (*Arctostaphylos uva-ursi* (L.) Spreng). Vegetation in the opening is a dense stand of grasses and forbs dominated by Idaho fescue (*Festuca idahoensis* Elmer), perennial lupines (*Lupinus* spp.), and strawberry (*Fragaria* spp.).

The climate of the area is typical of the subalpine zone of the western slope of the Front Range. Temperatures range from -40° to 90° F (-40° to 32° C) and precipitation from 18 to 34 inches (46 to 86 cm) annually. Haeffner (1971) provided a climatological summary of the experimental area.

Temperatures and precipitation during the summer—June through September—were important to this study. Average temperatures over a 31-year period (1940-1971) were: maximum 69.5° F (21° C), minimum 33° F (0.6° C), and mean 50° F (10° C). Average summer precipitation was 7.6 inches (19.3 cm), with a range from 5.7 to 9.5 inches (14.5 to 24.1 cm).

Temperature and precipitation data were measured at the headquarters station, approximately 1 mile (1.64 km) from the study area and less than 150 feet (45.7 m) higher in elevation than the study site.

The soil is classified as Tabernash loam and mapped as Tabernash loam and Mine gravelly loam. It developed from material weathered from mixed gneisses and schists, and was deposited over the study area from glacial outwash (Retzer 1962). Laboratory analysis, from mineral surface to 8 inches (20.3 cm) depth, showed approximately 30%, 47%, and 23% sand, silt, and clay, respectively. Moisture contents at tensions of minus $1/3$ and 15 bars were approximately 20% and 10% respectively.

Methods and Materials

Temperatures and precipitation were recorded on the study area during the summer of 1977 with a recording hygrothermograph and dial maximum-minimum thermometer in a standard U.S. Weather Bureau shelter. A standard 8-inch (2.03-cm) rain gage, without funnel or tube, was weighed weekly to measure precipitation.

In late September 1976, three 6-foot-square (1.8-square) seedbeds, each 20 feet (6.1 m) apart were hand scarified to mineral soil (fig. 2).



Figure 2.—Seedbed scarified to mineral soil. Plastic tags marked seedling locations.

Table 1.—Measurement of first-season lodgepole pine seedlings from the central Colorado Rockies.

| Measurement | Mean | Maximum | Minimum | Standard error |
|------------------------|------|---------|---------|----------------|
| Number of branch roots | 26.1 | 51 | 9 | 1.83 |
| Root/shoot ratio | 3.9 | 5.9 | 1.9 | 0.16 |
| -- in -- | | | | |
| Root depth | 3.8 | 5.3 | 2.5 | 0.10 |
| Total root length | 9.8 | 16.8 | 4.4 | 0.44 |
| Seedling height | 1.0 | 1.5 | 0.6 | 0.03 |

Immediately following scarification, approximately 1,000 seeds (local seed source with 65% laboratory germination) were sown on the surface of each seedbed.

Seedlings that germinated between June 4 and 10, 1977 were measured when they were 16 weeks old. Seedlings were carefully excavated with a shovel and trowel and the soil washed from the roots using a gentle rinsing action with a coarse soil-screen and a water-filled barrel.

Results

A total of 48 seedlings, 16 from each seedbed, were measured. Analyses showed no significant differences in rooting depth, number of branch roots, total root length, seedling height or root/shoot ratios among groups of seedlings from the three seedbeds. Therefore, seedling growth measurements were combined to calculate means, ranges, and standard errors (table 1).

Average temperatures were near normal during the 1977 growing season; with a 70.7° F (22° C) maximum; 36.5° F (2.5° C) minimum, and 53.6° F (12° C) mean. Precipitation, while poorly distributed, was 1.2 inches (3.0 cm) above normal.

Discussion and Conclusion

Data collected from one growing season indicated that 16-week-old lodgepole pine seedlings develop a shallow root system under field conditions. Rooting depth was approximately 3.8 inches (9.6 cm), with about 26 branch roots, and a total root growth of 9.8 inches (24.9 cm).

Lodgepole pine seedlings extend their roots to about the same depth during the first growing season as seedlings of Engelmann spruce (*Picea engelmannii* Parry), a common associate on the Fraser Experimental Forest (Noble 1973). However, lodgepole pine seedlings develop more than twice as many branch roots and almost twice the root length. The greater root development of intolerant

lodgepole pine, compared to spruce, may partly explain why lodgepole pine becomes established on drier sites than Engelmann spruce does.

Nevertheless, the lack of a deeper root system for lodgepole pine seedlings is a major factor contributing to mortality on both mineral soil and undisturbed areas. Under drought conditions, first-summer root growth may not be adequate to keep up with available soil moisture. Further, first-year seedlings with shallow root systems are probably more susceptible to frost-heaving, especially on mineral soil seedbeds.

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